

INSTRUCTION MANUAL FOR
MODEL #CF-1
AF SUBSTITUTION ATTENUATOR FOR
RF SQUARE LAW DETECTORS

Weinschel Engineering

KENSINGTON, MARYLAND



Weinschel Engineering Co., Inc.

10503 METROPOLITAN AVENUE, KENSINGTON, MD. Lockwood 4-0122

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Insertion Loss Test Sets

Bolometer Preamplifiers

Coaxial Terminations

Step Attenuators

Coaxial Attenuator Pads

Coaxial Power & Pulse Power Pads

INSTRUCTION MANUAL FOR

MODEL #CF-1

AS SUBSTITUTION ATTENUATOR FOR
RF SQUARE LAW DETECTORS

IM#4

18 Pages

ECN-CF-1-7

12/1/58

Bolometer Mounts

Keyboard Oscillator

Attenuation Standards

Power Measuring Bridges

Micro Potentiometers

Thermistor Mounts

For Standards of Attenuation Use Weinschel Engineering Co.'s Coaxial Pads

WEINSCHEL ENGINEERING
KENSINGTON, MARYLAND
TEST RECORD

A. F. SUBSTITUTION ATTENUATOR

MODEL CF-1

DATE 6-23-59

SERIAL NUMBER 100

CUSTOMER _____

JOB NUMBER _____

1. Attenuator Accuracy

Attenuation Setting	db error AF Power	db error RF Power
32 db	<u><.04</u> db	<u><.02</u> db
22 db	<u><.04</u> db	<u><.02</u> db
12 db	<u><.04</u> db	<u><.02</u> db
2 db	<u><.04</u> db	<u><.02</u> db
1 db steps (max. dev.)	<u><.04</u> db	<u><.02</u> db
Variable (max. dev.)	<u><.01</u> db	<u><.005</u> db

2. Cathode Follower Tests

Attenuation Setting	db error AF Power	db error RF Power
32 db	<u><.04</u> db	<u><.02</u> db
22 db	<u><.04</u> db	<u><.02</u> db
12 db	<u><.04</u> db	<u><.02</u> db
2 db	<u><.04</u> db	<u><.02</u> db
1 db steps (max.)	<u><.04</u> db	<u><.02</u> db
Variable (max.)	<u><.01</u> db	<u><.005</u> db

3. Cathode Follower Gain

	Input	Output
1,000 cps	20.0 V rms	<u>12.0</u> V rms
200 cps	20.0 V rms	<u>11.7</u> V rms
10,000 cps	20.0 V rms	<u>12.0</u> V rms

4. Gain Stability

Input 20.0 V rms 1,000 cps

Line Voltage = 105 VAC
Line Voltage = 125 VAC

Output

12.0 V rms
12.0 V rms

5. Noise Test: For Cathode Follower with 100K Ohms in Input

Noise (calculated referred to the input) .25 MV rms

Tested by

L. G. Smith

Engineer

H. L. Wilson

TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
ONE	GENERAL INTRODUCTION	4
	1.1 Scope of Manual	4
	1.2 Purpose of Instrument	4
	1.3 Specifications	5
	1.4 Description	6
	1.5 Other Uses	7
	1.6 Unpacking and Preparation for Use ...	8
TWO	THEORY OF OPERATION	10
	2.1 RF Attenuation	10
	2.2 Equipment Required	10
	2.3 Purpose of Equipment	10
	2.4 Design Considerations	11
	2.5 Other Sources of Error.....	13
THREE	OPERATING PROCEDURE	14
	3.1 Using Cathode Follower Input	14
	3.2 Using 2000 ohm Attenuator Only	14
	3.3 Making Substitution Measurements of R.F. Insertion Losses	14
	3.4 Reading .1 db Attenuation Changes ...	14
	3.5 Use As Attenuator Box	15
FOUR	MAINTENANCE	16
	4.1 General Maintenance	16
	4.2 Performance Checks	16



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LIST OF ILLUSTRATIONS

	<u>PAGE</u>
Photograph of Model CF-1 (P-49)	18
Block Diagram of Insertion Loss Test Set No. 1, Group 1, Dwg. B114-30, issue A	following 18
Photograph of Insertion Loss Test Set-up (P-12)	18
Block Diagram of Insertion Loss Test Set No. 3, Group 2, Dwg. B114-168	18
Schematic of Model CF-1, Dwg. C110-91	18
Table 1	18
Form #81 - Test Record	18

SECTION ONE

GENERAL INTRODUCTION

1.1 Scope of Manual.

This Instruction Manual covers the general introduction, theory of operation, operating procedure, and maintenance instructions for AF Substitution Attenuator for RF Square Law Detector, Model #CF-1.

1.2 Purpose of Instrument.

The instrument is designed for making audio frequency substitution measurements of R.F. losses when used with suitable accessory equipment listed in Table 1 of this manual. It is designed for insertion between the high impedance output of a bolometer preamplifier and the high impedance input of a VTVM. It reads directly in R.F. loss. Since the VTVM operates at a constant level, the inaccuracy of the VTVM does not contribute to the system error. With stable R.F. sources, accuracies of .1 db can readily be obtained for loss measurements to 30 db R.F. The block diagram of the set-up is shown on the attached Drawing B-114-30.

The accuracy is limited by the level change of the output of the R.F. generator during measurement, the non-linearity of the bolometer preamplifier, influence of noise when measuring R.F. losses over 20 db and the sensitivity of the indicating meter.

By use of the dual channel set-up described on the attached Drawing B114-168, a sensitivity of .01 db/10 and an accuracy of .02 db/10 db can be achieved for measurements of R.F. losses to 20 db even if the amplitude of the output of the R.F. source varies plus or minus .2 db during a measurement.

1.3 Specifications.

1.3.1 Dimensions: Standard relay rack panel 8 3/4" x 19" Maximum. depth behind panel 13 1/2". Weight 25 lbs. Panel, black crackle finish.

1.3.2 Ambient Temperature: 25°C. plus or minus 10°C.

1.3.3 Power Requirements: Nominal 115 volts plus or minus 10%, 60 cps, 95 VA.

1.3.4 Fuse: 2 amp, Bussman type AGC, is mounted on rear of chassis.

1.3.5 Connectors: Input and output: type "BNC", female jacks. Power line input: standard 115 volts, 2 wire recessed male cap.

1.3.6 Controls: "On-Off" Switch controls AC power; ruby pilot indicates power "on". A toggle switch selects the input either through a cathode follower ("cathode follower") or directly into the attenuator ("2000 ohms"). Attenuator controls all marked in R.F. db - four 10 db steps can be inserted by means of lever switches, one attenuator is variable in 1 db steps from 0-10 db, another attenuator covers 0-1 db in one step and 1-2 db in 10 steps each. Total attenuation is 50 db.

1.3.7 Gain: Cathode Follower has a gain of about .5.

1.3.8 Maximum Input: a) to cathode follower 30 volts RMS.

b) to attenuator, when bypassing cathode follower
15 volts RMS.

1.3.9 Input Impedance: a) Cathode follower; above 1 megohm.

b) Direct to attenuator: 2000 ohms.

1.3.10 Attenuator Accuracy: $\pm .02$ db from 0-30 db consisting of

a) Accuracy at DC: $\pm .01$ db (R.F.)

b) Difference of attenuator calibration at 1,000 cps compared with D.C. including influence of crosstalk: $\pm .01$ db (R.F.) for maximum insertion of 30 db (R.F.).

1.3.11 Non-linearity of Cathode Follower input vs. output at

1,000 cps: Up to a maximum of 30 volts RMS; $\pm .01$ db (R.F.)

1.3.12 Output Impedance: 2000 ohms, for use with high-impedance external VTVM.

1.3.13 Audio Frequency: Instrument is designed for use at 1,000 cps; however, its response is good from 100 cps to 10 kc when using "Cathode Follower" input and D.C. to 10 kc when using the "2000 ohms" or direct input.

1.3.14 Noise: Less than .5 MV RMS, contributed by the cathode follower.

1.4 Description.

1.4.1 The attached photograph P-49 shows a front view of the A.F. Substitution Attenuator for R.F. Square Law Detector, Model #CF-1, designed for operation at 1,000 cps. The panel indicates directly R.F. attenuation from 0-50 db. The actual attenuation at 1,000 cps is twice the attenuation marked on the panel.

The equipment contains well shielded precision wirewound 2000 ohm attenuator sections driven by a power cathode follower. It is designed for making A.F. substitution measurements facilitating the measurements of R.F. insertion loss, and can be used with or without the cathode follower stage depending on the output impedance of the equipment used to supply the A.F. signal to the A.F. Substitution attenuator.

1.4.2 The instrument is self contained with a built-in power supply for operation from standard ac power. The cathode follower has a maximum loss of 6 db (.5 gain) and is linear to a maximum input voltage of 30 volts with a very low noise level.

1.4.3 Four, fixed steps 10 db attenuation can be inserted by means of four panel mounted lever switches. An additional 10 db in .1 db steps can be inserted by means of two rotary switches. A calibrated continuously variable attenuator provides .01 db graduations from minus .02 db to plus .11 db.

1.5 Other Uses for the Model ~~FCF~~-1.

1.5.1 The instrument can be used for making all kinds of precision insertion loss measurements around 1,000 cps in circuits varying in impedance to 1 megohm, by using the cathode follower to match the output impedance of the test circuit to the A.F. substitution attenuator.

1.5.2 The cathode follower can be switched out of circuit, and the 2000 ohm attenuator used directly.

1.5.3 When used with Weinschel Model ~~MD~~-1 Differential Null Detector, ~~FCF~~-1 is used for precision measurements of r-f insertion loss dual channel set-ups which eliminate errors due to amplitude variations of the R.F. sources.

The attached block diagram R114-169 shows the set-up of the paralleled R.F. channels both fed from the same R.F. source. One channel is the regular "Measurement Channel," and the "Bucking Channel." A level change of the output of the R.F. source by plus or minus .2 db will unbalance the

null indication by less than the equivalent of .01 db R.F.

The sensitivity of this set-up is such that measurements between 0 and 10 db can be repeated to .01 db and measurements between 10 and 20 db can be repeated between .01 db and .02 db.

The method is described in greater detail in the Instruction Manual covering the Differential Null Detector Model FND-1.

1.6 Unpacking and Preparation For Use.

The instrument is packed in a standard double container with 3" of packing material between the inner and outer case. The only extra items are this Instruction Manual and the line cord. Normal care should be exercised when removing the instrument from the case, and removing packing material. Examine the packing to be sure that there are no loose items before discarding it.

Tubes are shipped in position, and are locked in place with tube clamps. After unpacking, examine the instrument for damage. If any is found, notify the shipping company immediately; if none is found, proceed with preparations for use.

1.6.1 Make certain that the tubes are properly seated in their sockets and that there is no apparent mechanical change. Check to see if the fuse in the holder broke in transit. Then plug the line cord into a suitable AC outlet.

If the input is switched to "2000 ohms", there is no need to turn on the ac switch because the cathode follower is not used and direct connection is made to the attenuator.

Switch the instrument to "on" by means of the "on-off" toggle switch; the ruby pilot will light at once. Allow 50 seconds for the tubes to warm up and stabilize.

The instrument is now ready for use.

SECTION TWO

THEORY OF OPERATION

2.1 RF Attenuation.

The unknown attenuation of a microwave component may be determined very conveniently and accurately by a method of measurement known as the "Ballantine Voltmeter Method." (For a discussion of this method, see pages 806-808 and 838-841 of Volume 11 of the Radiation Lab. Series, "Technique of Microwave Measurements" by C. G. Montgomery).

2.2 Equipment Required.

The equipment required to make this type of measurement is tabulated in Table 1. A typical insertion loss test set-up is illustrated in the attached block diagram Drawing B114-30. Such a test set-up is also shown in the attached photograph P-12.

2.3 Purpose of Equipment.

The A.F. Substitution Attenuator for R.F. Square Law Detector has been designed for insertion between the high impedance output of a bolometer preamplifier and the high impedance input of a level indicator for 1,000 cps such as, e.g., a V.T.V.M.

In the absence of this Substitution Attenuator, the ratio of 2 output voltages of the bolometer preamplifier is obtained by taking 2 readings of the V.T.V.M; the accuracy of these readings is mainly a function of the multiplier resistors and scale linearity of the V.T.V.M.; if, e.g., each reading is 2% inaccurate, the maximum error of the voltage ratio is 4%. A 4% error of the voltage ratio causes a 4% error of the measured power ratio or an error of about .2 db in the measured R.F. attenuation.

By inserting the substitution attenuator between the bolometer preamplifier and the V.T.V.M., it is possible to operate the V.T.V.M. at the same level of 2 output voltages of the bolometer preamplifier by inserting more or less attenuation. The difference of the 2 attenuator settings maintaining the same V.T.V.M reading for the 2 output voltages is the voltage ratio in db.

Since R.F. square law detectors are used the R.F. power ratio equals the A.F. voltage ratio. This means that a change in the AF level expressed in db will be twice the change in RF level also in db. This substitution attenuator has been marked to read directly in R.F. db. (Actually a change of 10 db R.F. corresponds to a 20 db in A.F.)

2.3.1 Calibration - The Model CF-1 is intended for use with a r-f square law detector. Consequently, when making r-f measurements, the actual value of RF insertion loss is read on the attenuator. When making a-f measurements, the attenuation in db as read on the attenuator, should be doubled as explained before.

2.4 Design Consideration.

When designing an accurate step attenuator for 1,000 cps to cover a range of 80 or 100 db audio, one must consider the reactance of wirewound resistors, capacity between switch contacts, capacity between switch contacts and ground, capacitive, magnetic and galvanic coupling between high level input and low level output sections.

The long term stability is a function of the resistors and the wearing of the switch contacts.

The output impedance of the companion instrument, the BA-1 Bolometer Preamplifier, requires a load of about 1 megohm. It is difficult to design accurate attenuators at 1,000 cps having such a

high impedance due to the importance of stray capacities. It was therefore decided to use a low impedance attenuator fed from a power cathode follower.

In order to maintain a linearity of .01 db (audio) for a maximum input of 30 volts to the cathode follower, it was found that the load of the cathode follower could be as low as 2,000 ohms.

When the input switch is set to "2000 ohms" it bypasses the cathode follower and couples directly into the 2000 ohm attenuator without coupling condensers. When the input switch is set to "cathode follower", the input is connected to the grid of the cathode follower through a condenser and the cathode in turn is connected to the 2000 ohm attenuator through a condenser. The loss through the cathode follower is about 6 db (audio). The noise generated by the cathode follower as measured on a broadband average reading V.T.V.M. is below 500 microvolts. In selecting the 6AS7, advantage was taken of the characteristics of two sections of a twin triode in parallel. In addition, the 6AS7 has a very low output impedance, draws a heavy plate current and can handle large grid voltages without departing from the linear characteristics which are essential in a cathode follower stage driving a precision attenuator.

The operating frequency can be between 400 cps and 10000 cps. The termination of the 2000 ohm precision attenuator of the model #CF-1 consists of a potentiometer and a series resistor as shown in schematic diagram (drawing C110-91). The wiper contact of the potentiometer is connected to the output. It forms a continuously variable attenuator calibrated to read (from -.01db to +.11db) in .01 divisions. To maintain the accuracy of this attenuator, the input impedance of the indicator following the CF-1 should be 1 megohm or higher.

2.5 Other Sources of Error.

Concerning R.F. loss measurements, errors due to reflection interactions and crosstalk are discussed on pages 824 and 830 of "Technique of Microwave Measurements" by Montgomery (Vo. 11, M.I.T. Radiation Lab. Series, McGraw-Hill).

SECTION THREE
OPERATING PROCEDURE

3.1 Using Cathode Follower Input.

If the output impedance of the source, or circuit, working into the instrument has a high impedance, and would be seriously loaded by a 2000 ohm input impedance, the "cathode follower" circuit should be used. This merely involves switching on the ac power to the instrument, and setting the input switch to "cathode follower."

3.2 Using 2000 Ohm Attenuator Only.

If it is desired to use the attenuator in a 2000 ohm circuit, it is only necessary to set the input selector to "2000 ohms. The ac power need not be turned on.

3.3 Making Substitution Measurements of R-F Insertion Losses.

The equipment needed to make r-f insertion losses is shown in Dwg. B114-30 and the method employed is described fully in the Instruction Manual for the BA-1 Bolometer Preamplifier (DM#1). When following the block diagram of Dwg. B114-30, the cathode follower input should be used. As shown in paragraph 2.4 input impedance of the VTVM should be 1 megohm or higher.

3.4 Reading .1 db Attenuation Changes:

It will be noted that the calibration of the 0-2 db range on the attenuator goes from 0-1 db, and then progresses in .1 db steps to 2 db. To read changes of .1 db, it is only necessary to insert 1 db and raise the gain of the BA-1 Preamplifier, or output meter, to read the same as before. Then the .1 db steps can be used to read changes of .1 db.

The insertion loss of the attenuator under test is then read as the number of db removed from the circuit to obtain the original reading on the output meter. In other words, the insertion loss is read directly on the attenuator.

3.5 Use As Attenuator Box.

If the input switch is operated to "2,000 ohms" and the power switch is operated to "off," the unit may be used as a precise stepattenuator, from DC through the lower audio range. However, it is necessary to multiply all DB markings by two.

SECTION FOUR

MAINTENANCE

4.1 General Maintenance.

Maintenance requirements on this equipment are very simple. If the operation of the cathode follower stage is doubted, standard mutual conductance checks should be made on the 6AS7 tube. The B+ voltage should also be checked with a high resistance voltmeter and should be approximately 250 volts. Because the cathode follower is operating as an impedance changing device and the gain does not enter into the results obtained (provided of course that it does not change during the time a measurement is being made), its operation is not critical. However, stable operation is naturally desirable, and erratic operation of this stage can be quickly traced using ordinary voltage, resistance, and capacity checks.

4.2 Performance Checks.

4.2.1 Attenuator calibration can be checked by using a standard substitution test set-up to measure the actual attenuation and by going into the attenuator through the "2000 ohms" position. It should be remembered that the calibrated db attenuation shown must be doubled when using a-f for testing.

4.2.2 Cathode follower noise must be less than .5 MV RMS. To check this, the input is terminated with a 100 K resistor selector in "cathode follower" position, and a VTVM is placed across the attenuator output. If the noise is higher than .5 MV change the 6AS7. Ruggedized tubes should be used and checked.

for noise in the actual instrument. Usually about one in two will check "good".

4.2.3 Cathode Follower Gain can be checked by applying 10 volts RMS to the input with the selector in "cathode follower" position. It should be possible to read not less than 5 volts at the output terminal with all attenuators set to zero.



P - 49

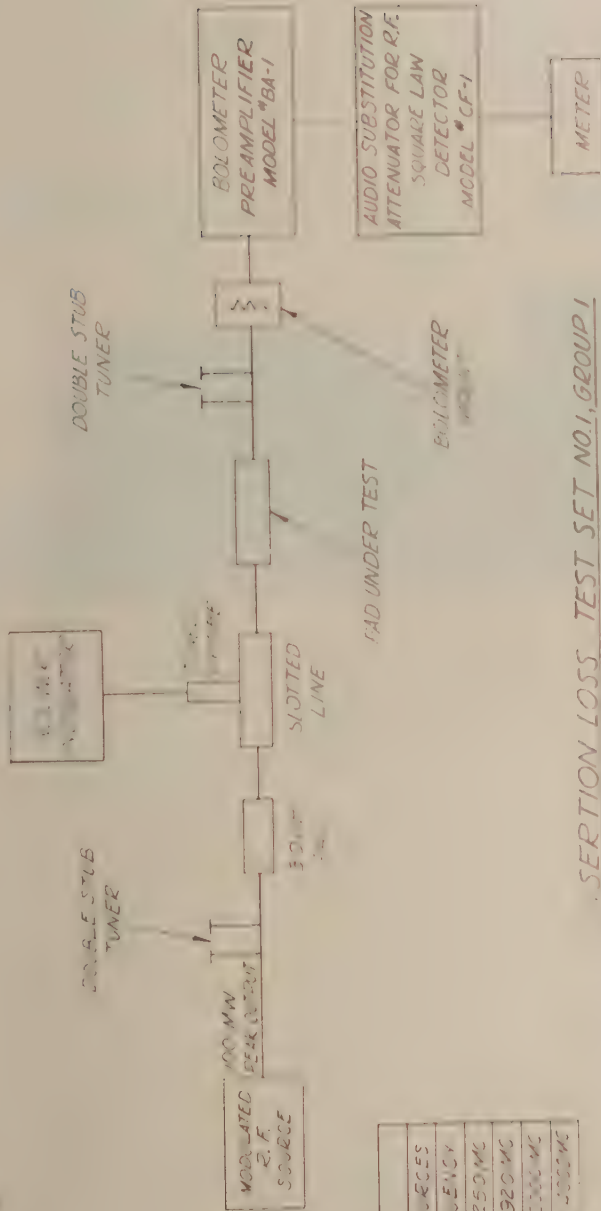
AF Substitution Attenuator For RF Square Law
Detectors.

IM #4

TOLERANCES

ALL 3 PLACE DECIMAL DIMS $\pm .003$
 ALL 2 PLACE DECIMAL DIMS $\pm .01$
 ALL FRACTIONAL DIMS $\pm .01$
 ALL ANGLES $\pm 15'$
 UNLESS OTHERWISE SPECIFIED

LIST OF	
MODULATED R.F. SOURCES	
MODEL NO.	FREQUENCY
MS-1	50-250 MC
MS-2	250-920 MC
MS-3	900-1500 MC
MS-4	2000-10000 MC



SECTION LOSS TEST SET NO.1, GROUP I

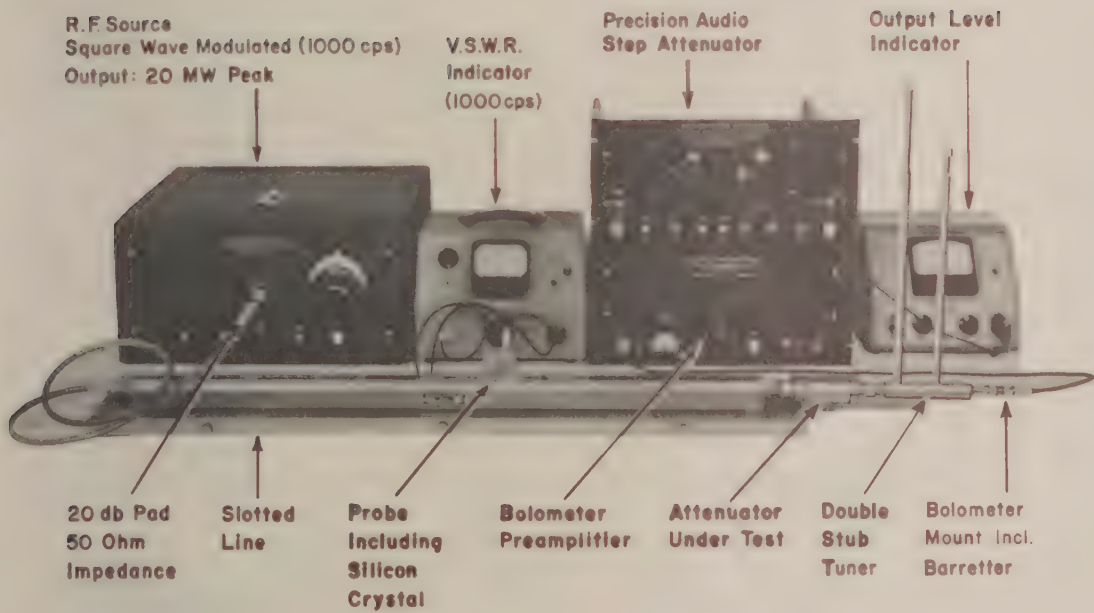
- NOTES:
- 1-30 DB CAN BE MEASURED IN ONE STEP BY USING THE BA-1 AND CF-1.
 - 2- IF THE GENERATOR OUTPUT IMPEDANCE IS ADJUSTED TO PRESENT THE PROPER SOURCE IMPEDANCE, THIS RANGE MAY BE EXTENDED TO 60 DB BY THE USE OF A CALIBRATED 30 DB PAD APPLYING THE R.F. SUBSTITUTION METHOD.

Wendel Engineering Co.	
1000 SPRING RD.	
INJECTION LOSS TEST SET NO.1	
GROUP I 0-30DB (0-60DB)	
MATERIAL	
FINISH	
SCALE	
B 1.7 30 1	

REVISIONS

APPROVED BY: 1-23-55

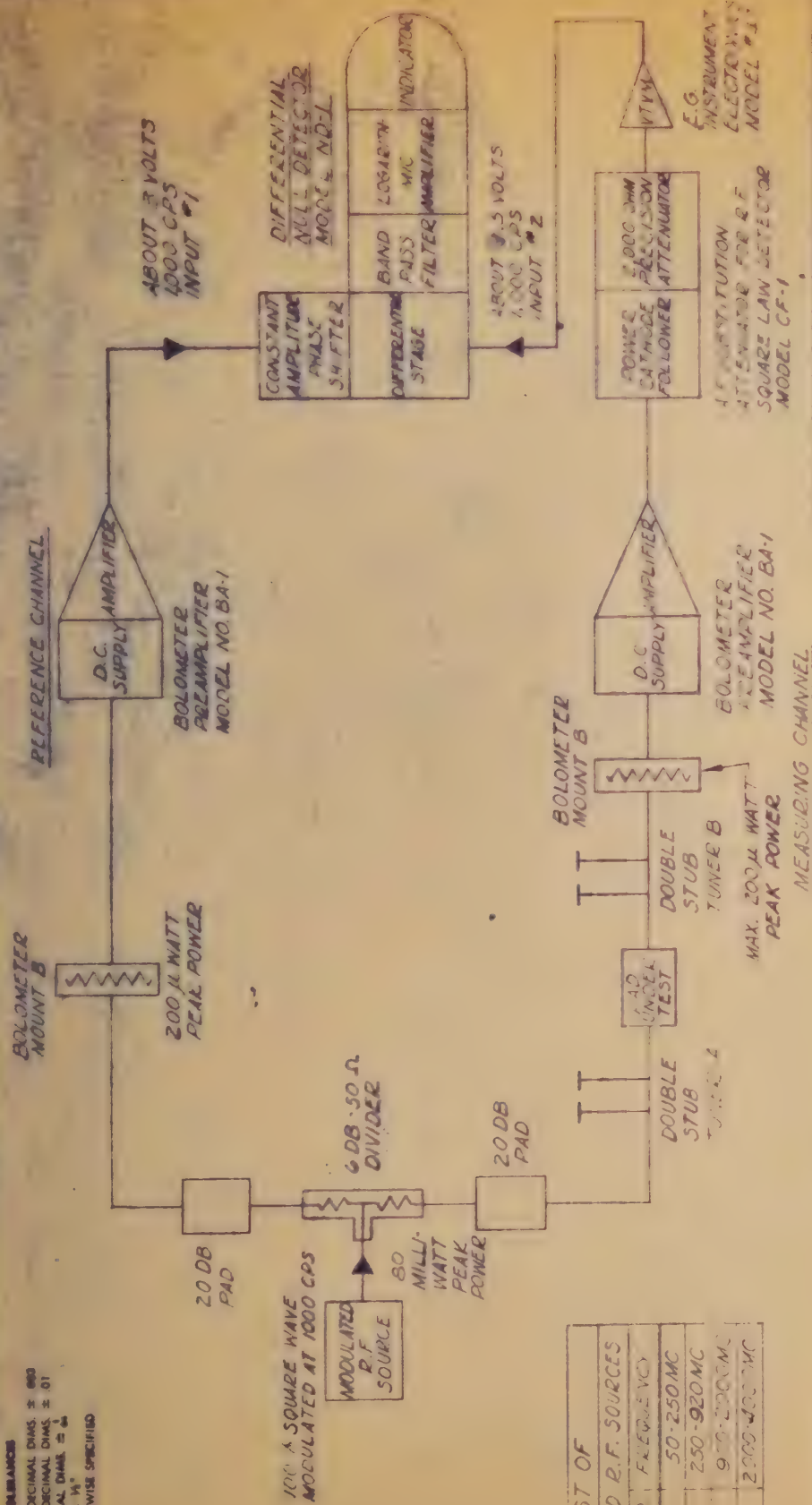
**TYPICAL INSERTION LOSS TEST SET
RANGE 0 - 30 db**



P-12

VIEW OF INSERTION LOSS TEST SET
SHOWN IN BLOCK DIAGRAM B-114-30

ALL 3 PLACE DECIMAL DIMS. $\pm .003$
ALL 2 PLACE DECIMAL DIMS. $\pm .01$
ALL FRACTIONAL DIMS. $\pm \frac{1}{64}$
ALL ANGLES $\pm 14^\circ$
UNLESS OTHERWISE SPECIFIED



NOTE
1-0-20 DB CAN BE MEASURED IN ONE STEP BY USING
2 BA-1, 1 CF-1, MD-1, INSTRUMENT ELECTRONICS #17

USE ON	ARB. DATA	WEINSCHEL ENGINEERING CO.	
		SILVER SPRING, MD.	
		INSERTION LOSS TEST SET NO. 2	
		Q-2008 GEAR P. 2	
		MATERIAL _____	
		FINISH _____	
		C	SCALE _____
		D 2002	
		7-12-55	
		Y	8/14/60

Weinschel Engineering Co.

DAVID SPRING, MD.

INSERTION LOSS TEST SET NO. 2

7-2002-24002

MATERIAL

PICTURE

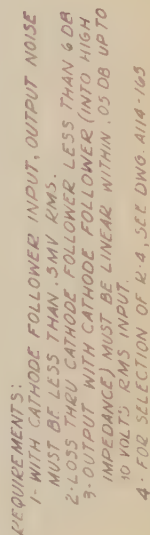
25-17-55
2770

200

111-102

REVISIONS

1



NOTE: ONLY TWO TYPICAL SWITCHES OF FOUR ARE SHOWN

NOTE: THE ACTUAL ATTENUATION IS TWICE THE ATTENUATION SHOWN.

USED ON	4397 ORNG
DATE	
Wenschel Engineering Co.	
SILVER SPRING, MD.	
SCHEMATIC, MODEL CF-1	
CATHODE FOLLOWER	
MATERIAL	
FINISH	
QTY	1
SCALE	
DATE	11-9-51
BY	

REVISIONS	DATE	BY	REASON
1	10/10/10	10/10/10	10/10/10

TABLE 1
RECOMMENDED EQUIPMENT

Freq. Range kmc	Type Trans. Line	Type Bolom- eter Mount	Type Bar- retter	Signal Sources	Slotted Line	Output Level Indicator	Audio Step Atten- uator	VSWR Ind.	Stub Tuner
.20 to 1.00	Coax. 50 ohm	PRD623	PRD629A	HP608A HP612A GR1211A GR1215A GR-1208A GR1209A	100- 2000 mc Rollin 62 HP805A 400- 4000mc	BAL 300 or IE 47	WEC 2000- 62 or CF-1	HP415A	From 4 to 4 kmc WEC DS- 109L
1.00 to 10.0	Coax. 50 ohm	PRD627A HP475B PRD613	PRD631C HP G28A PRD610A	HP612A HP614A HP616A HP618B HP624B GR 1218A Oscil- lator Tubes	HP809B PRD200 2000 10,000 mc				From 1 to 10 kmc PRD 306 WECDS109
8.2 to 12.4		PRD613	PRD610A	SP2K39 VAR X-13					
12.4	Wave Guide RG-107/U	PRD616	PRD614	SP SRU-54 VAR X-12 SP SRU-55	HP P810B				
18.0 to 26.5	Wave Guide RG-66/U	PRD621	PRD614	RAY QK-306 RAY 2K33 SPSMK40	PRD211				
26.5 to 40.0	Wave Guide RG-96/U	PRD618	PRD617	RAY QK-289 RAY QK-290 SPSRV38 RAYQK291 RAYQK292	PRD212				

Key:

BAL - Ballantine	RAY - Raytheon
GR - General Radio	Rollin - Rollin
HP - Hewlett Packard	SP - Sperry
IE - Instrument Electronic	VAR - Varian
PRD - Pytechnic R. & D.	WEC - Weinschel Engr.

WEINSCHEL ENGINEERING
KENSINGTON, MARYLAND
TEST RECORD

A. F. SUBSTITUTION ATTENUATOR

MODEL CF-1

DATE 6-25-59

SERIAL NUMBER 100

CUSTOMER _____

JOB NUMBER _____

1. Attenuator Accuracy

Attenuation Setting	db error AF Power	db error RF Power
32 db	<u><.04</u> db	<u><.02</u> db
22 db	<u><.04</u> db	<u><.02</u> db
12 db	<u><.04</u> db	<u><.02</u> db
2 db	<u><.04</u> db	<u><.02</u> db
1 db steps (max. dev.)	<u><.04</u> db	<u><.02</u> db
Variable (max. dev.)	<u><.01</u> db	<u><.005</u> db

2. Cathode Follower Tests

Attenuation Setting	db error AF Power	db error RF Power
32 db	<u><.04</u> db	<u><.02</u> db
22 db	<u><.04</u> db	<u><.02</u> db
12 db	<u><.04</u> db	<u><.02</u> db
2 db	<u><.04</u> db	<u><.02</u> db
1 db steps (max.)	<u><.04</u> db	<u><.02</u> db
Variable (max.)	<u><.01</u> db	<u><.005</u> db

3. Cathode Follower Gain

	Input	Output
1,000 cps	20.0 V rms	<u>12.0</u> V rms
200 cps	20.0 V rms	<u>11.7</u> V rms
10,000 cps	20.0 V rms	<u>12.0</u> V rms

4. Gain Stability

Input 20.0 V rms 1,000 cps	Output
Line Voltage = 105 VAC	<u>12.0</u> V rms
Line Voltage = 125 VAC	<u>12.0</u> V rms

5. Noise Test: For Cathode Follower with 100K Ohms in Input

Noise (calculated referred to the input) .25 MV rms

Tested by Glushak Engineer Alison

www.manualsplus.com



1030701